SSRF CONTROL SYSTEM

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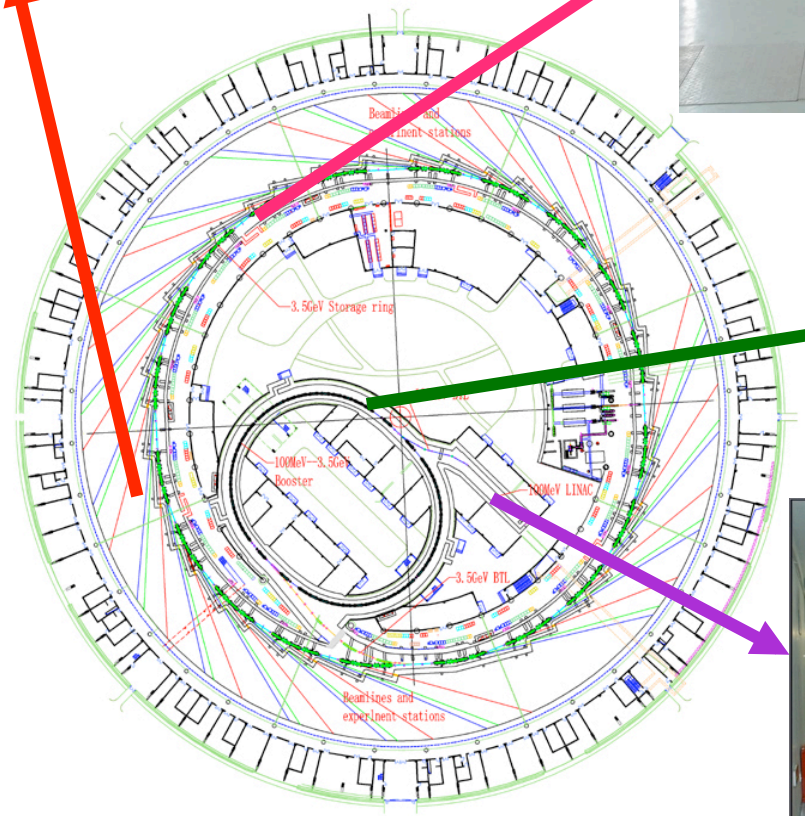
SSRF Layout

Beamline

s



3.5GeV Storage Ring

C=432m

3.5GeV Booster

C=180m

150MeV

Linac

phase 1 Beamlines

SSRF is a 3rd generation synchrotron radiation light source and aimed mainly at following research fields (at present) :

- **Biological Sciences**
- **Physical and Materials Sciences**
- **Earth and Environmental Sciences**
- **BioMedical, Chemical and Industrial applications**

BL08U1	Soft X-ray scanning spectroscopy
BL13W1	X-Ray Imaging
BL14B1	X-Ray diffraction
BL14W1	XAFS
BL15U1	Microfocusing
BL16B1	Small angle X-Ray Scattering
BL17U1	Protein crystallography

SSRF User proposals for 2009 (up to 2009-3-31)

Beamline	Proposals	Beamtime request (shift/8hr)
BL08U1(**SXSM)**	30	~ 246
BL13W1(**X-Ray Imaging)**	40	~ 297
BL14B1(**XRD**)	40	~ 245
BL14W1(**XAFS)**	65	~ 545
BL15U1(**Microfocusing)**	43	~ 352
BL16B1 **(SAXS)**	32	~ 265
BL17U1(**MX)**	51	~ 906
Total	301	2868 (~23000hr)

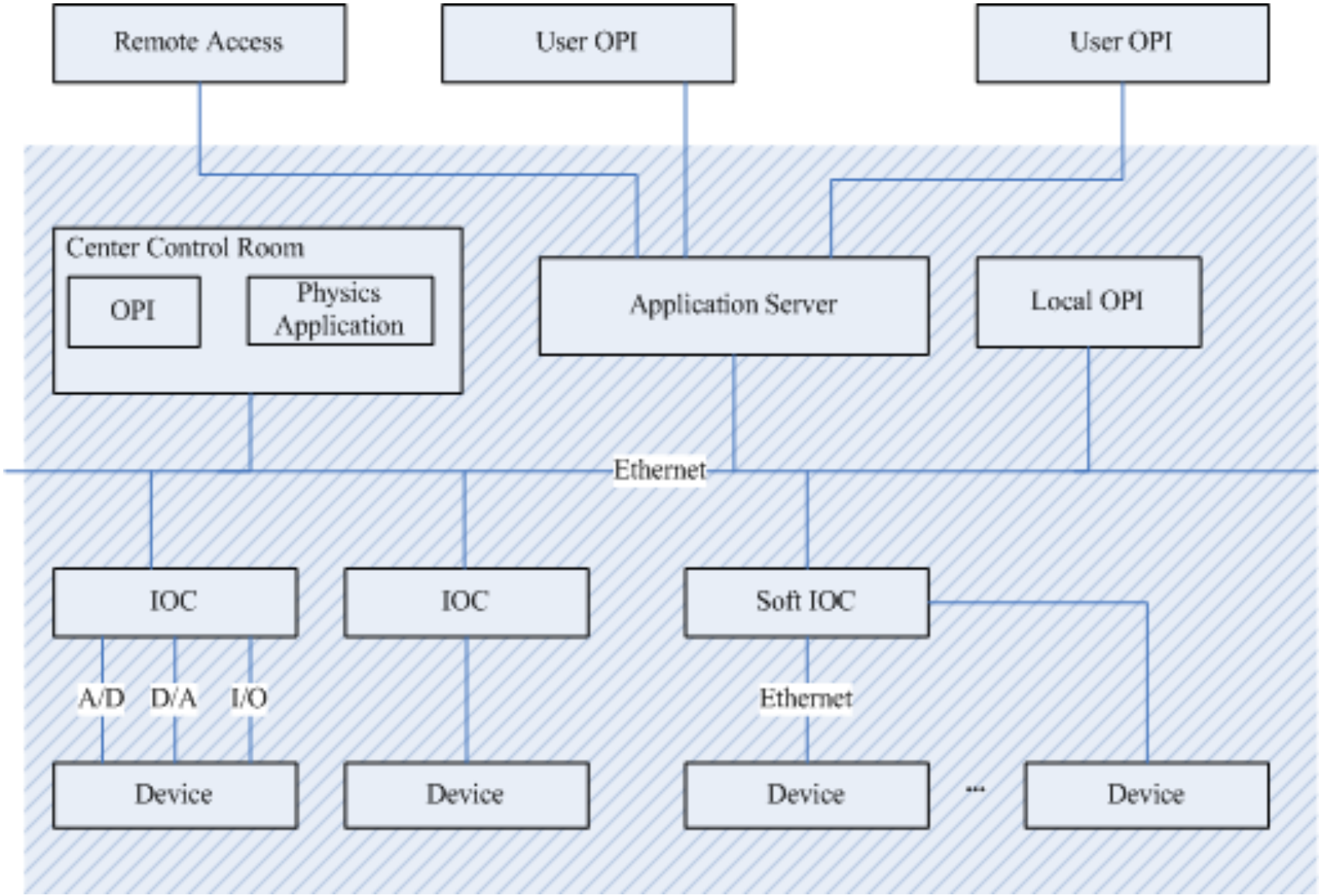
SSRF Control System

- SSRF control system is large scale real time control system running with high reliability and stability over 2 years in success.
- The SSRF control system adopted various advanced digital processing system
- Integrated with new computer technique and many hardware and software on the market

Overview

- EPICS based control system
- Connected by 2G Backbone Ethernet with backbone redundancy for the whole system
- Using Ethernet as fieldbus
  - Ethernet based PLC
  - Serial 2 Ethernet translate for serial device
  - Soft IOC
- Centralized application server at server room

Structure


Remote Access
User OPI
User OPI
Center Control Room
OPI
Physics Application
Application Server
Local OPI
Ethernet
IOC
IOC
Soft IOC
A/D
D/A
I/O
Ethernet
Device
Device
Device
...
Device

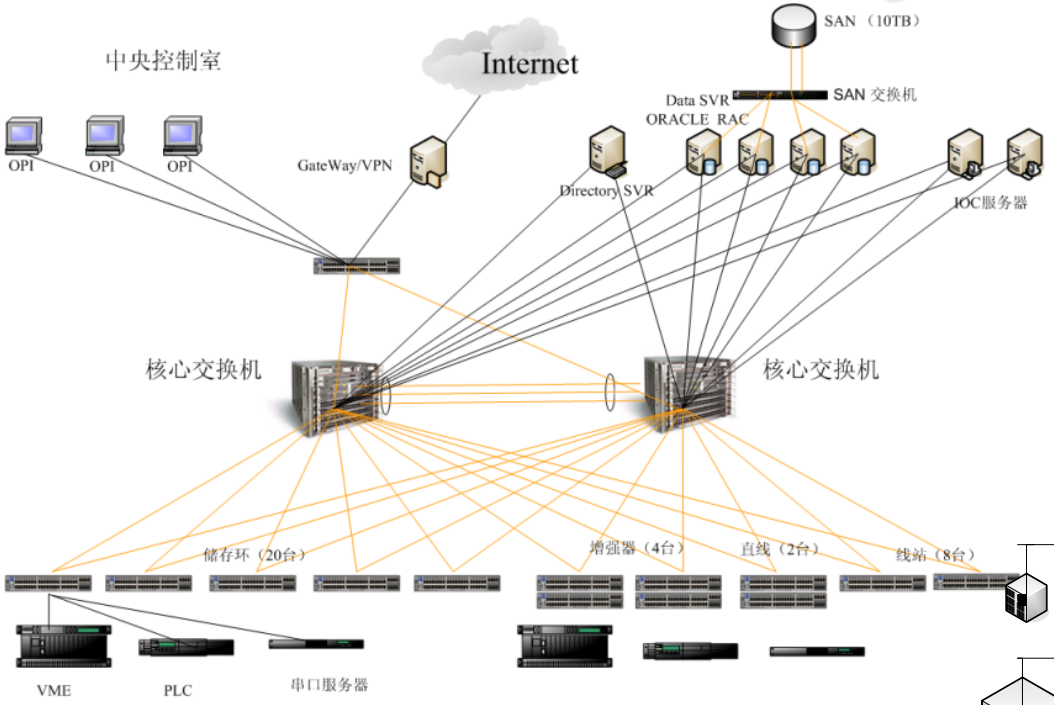
Environment of Control system

- Set up the environment of control system, used during phase of construct & in runtime.
- Composed with the control system network system, server system and OPI system.
- Uniform running and development software environment.
- Developer and operator can login in on any terminal and share resource of entire environment with one account system(NIS/AD).

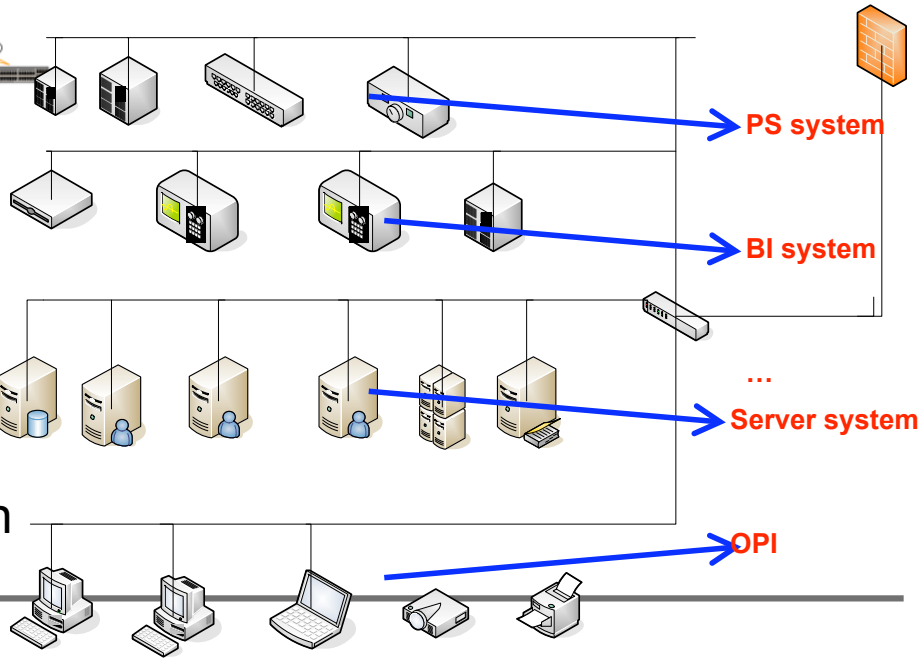
Centralize EPICS Develpoment platform

- Software
  - OS
    - Linux FC7/Kernel 2.6x/GCC 4.xx
  - EPICS base
    - 3.13.9/**3.14.8.2**/3.14.7/3.14.6/3.14.5
  - Extensions
    - Edm/medm/SDDS/Archiver/Sequencer/etc.
  - Cross-compiler environment
    - Gcc 2.8x/gcc 2.96/gcc 2.96 patch
- Target
  - Motorola VME 5500/GE VME 7050/ Motorola VME2302

Control System Network



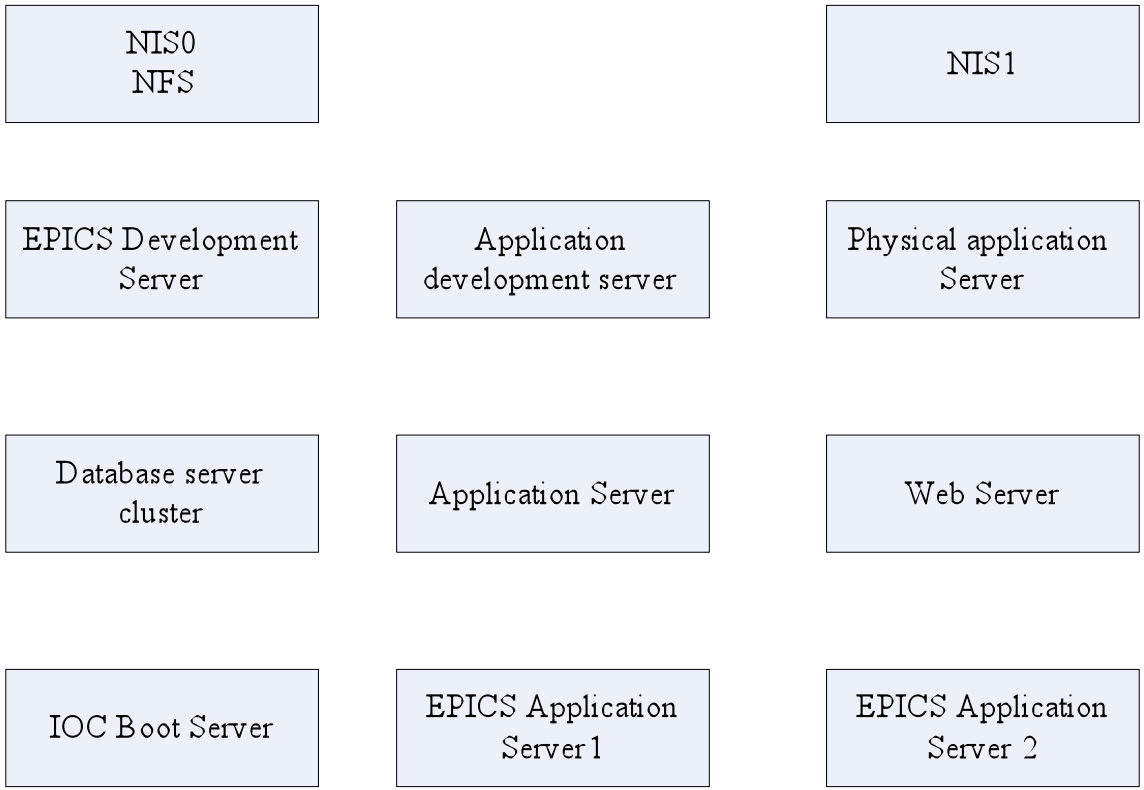
- backbone reach 2G.
- Control system sub lan by VLAN
- Division and recombine
- Full Network manage ability and application oriented Qos
- Backbone redundancy design to ensure reliability
- Remote access and monitor



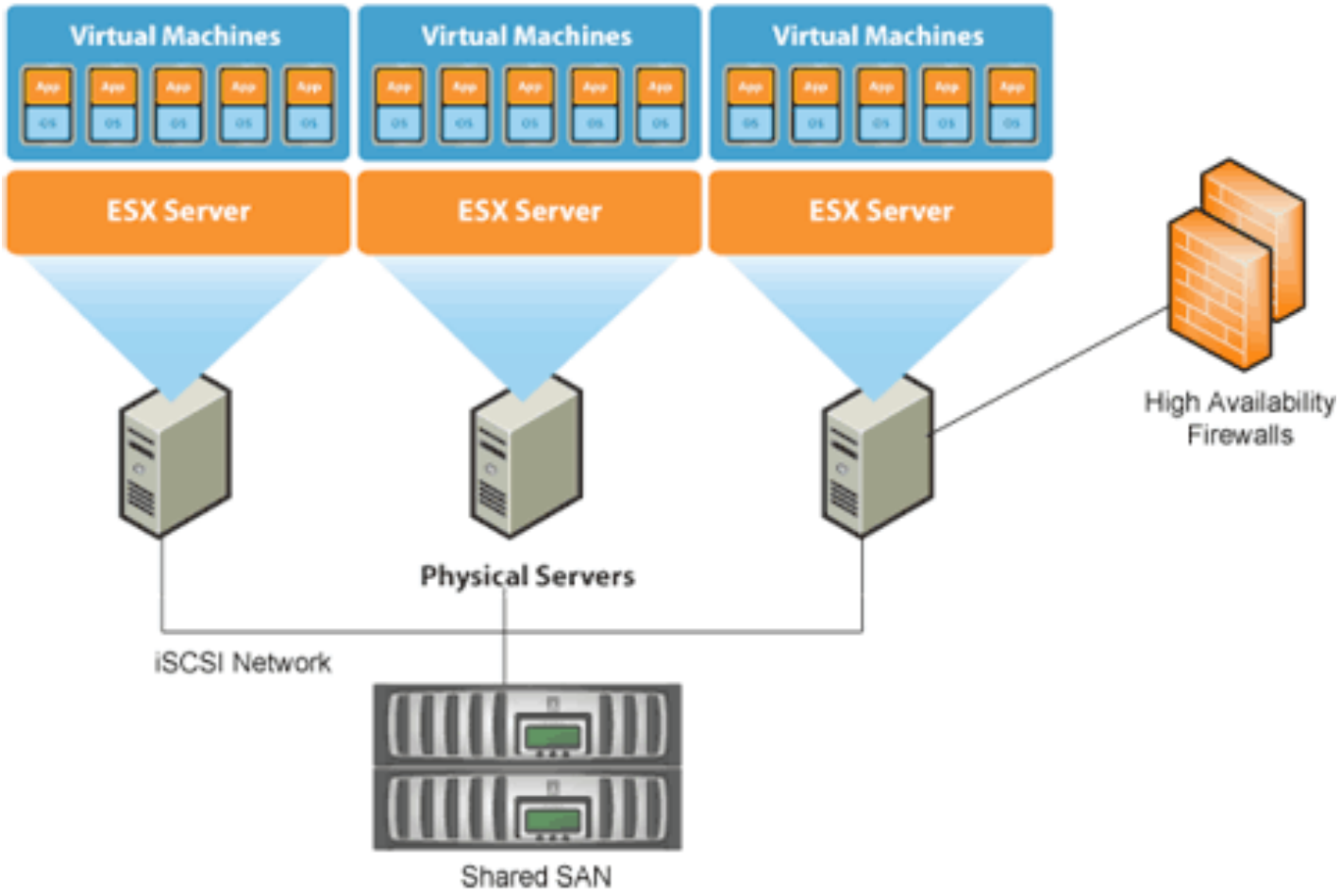
- Sub system division by VALN
  - 10.30.X.X/24
- Static 3 layer route table
- Access List table for access control
- Can be integrated other system easy in future

Server System

- Two kinds of server:
  - Linux & Windows Server
    - Integrated with Windows UNIX service 3.5
  - The operation system
    - Fedora core 7
    - Windows 2003 R2 64bit & 32bit
- Different application on different type of server
  - NIS, YUM, PXE, NFS, NTP, Windows AD, Epics Boot, Soft IOC, Archive, Alarm, Database, Web Service, WEB, e-Log etc.
- User's home on one NFS Server


NIS0
NFS
NIS1
EPICS Development Server
Application development server
Physical application Server
Database server cluster
Application Server
Web Server
IOC Boot Server
EPICS Application Server 1
EPICS Application Server 2

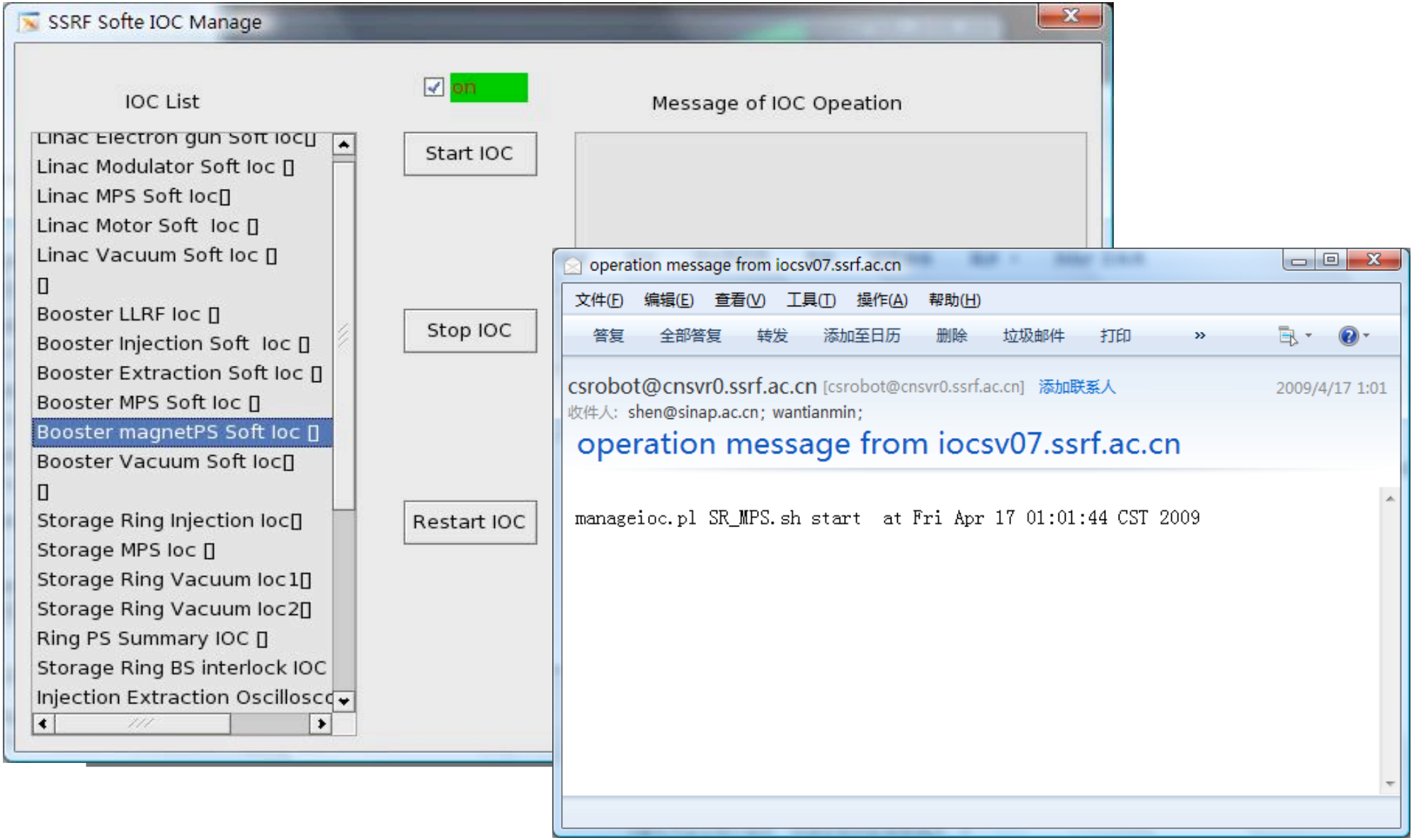
Virtual Machine



Soft IOC

- Multi-IOC running configure system
- Through a configure file, IOC can be stop, start, restart and set to be auto start state.
- The IOC management system will check the state of each IOC running state, if IOC crashed, it will be restarted.
- Inform with email or SMS

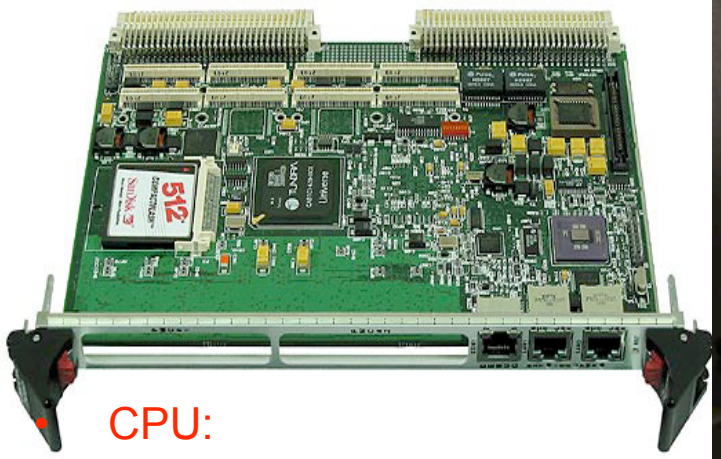
IOC Manager


SSRF Softe IOC Manage
IOC List
on
Message of IOC Opeation
Linac Electron gun Soft Ioc[]
Linac Modulator Soft Ioc []
Linac MPS Soft Ioc[]
Linac Motor Soft Ioc []
Linac Vacuum Soft Ioc []
[]
Booster LLRF Ioc []
Booster Injection Soft Ioc []
Booster Extraction Soft Ioc []
Booster MPS Soft Ioc []
Booster magnetPS Soft Ioc []
Booster Vacuum Soft Ioc[]
[]
Storage Ring Injection Ioc[]
Storage MPS Ioc []
Storage Ring Vacuum Ioc1[]
Storage Ring Vacuum Ioc2[]
Ring PS Summary IOC []
Storage Ring BS interlock IOC
Injection Extraction Oscillosc
Start IOC
Stop IOC
Restart IOC
operation message from iocsv07.ssrf.ac.cn
文件(F) 编辑(E) 查看(V) 工具(T) 操作(A) 帮助(H)
答复 全部答复 转发 添加至日历 删除 垃圾邮件 打印
csrobot@cnsvr0.ssrf.ac.cn [csrobot@cnsvr0.ssrf.ac.cn] 添加联系人
2009/4/17 1:01
收件人: shen@sinap.ac.cn; wantianmin;
operation message from iocsv07.ssrf.ac.cn
manageioc.pl SR_MPS.sh start at Fri Apr 17 01:01:44 CST 2009

Hardware system

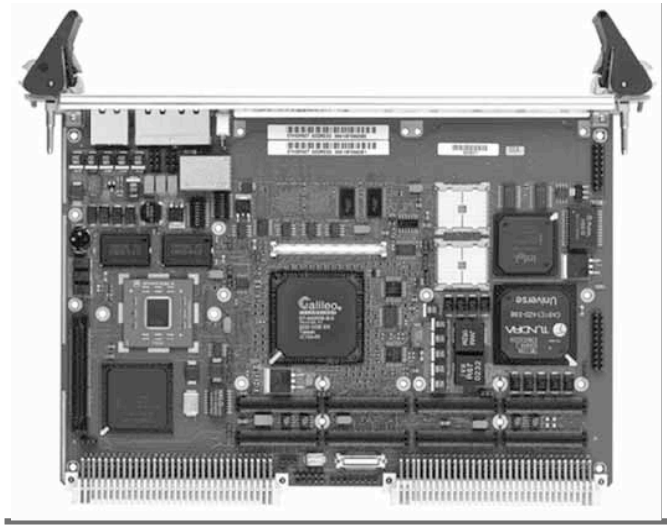
- Uniform hardware design, as typical implementation of SSRF control system have:
  - Ethernet everywhere
  - VME 64x System : GE VMIVME-7050 and Motorola MV5500.
  - PLC system: Yokogawa FM3, SIEMENS S300.
  - Serial port server MOXA NPort-5610.
  - The embedded controller: Digital power supply controller
  - VME board:
    - Timing system: VME-EVG-230, VME-EVR-230, EVR-TTB-200, EVR-OTB-200
    - PS control system: VIPC 664
  - Linux PC server (Soft IOC)

VME 64X System



CPU:

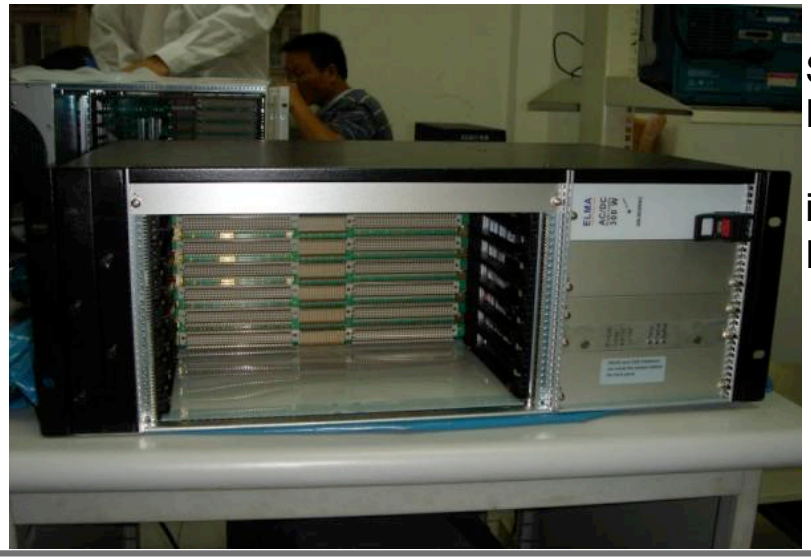
- Motorola MV5500
- GE VMIVME-7050



VME 64X crate by Elma

4U 7Slot
9U 12 Sloat

With the crate monitor system with Ethernet or Serial port



Support Telnet, Http

integrated with EPICS

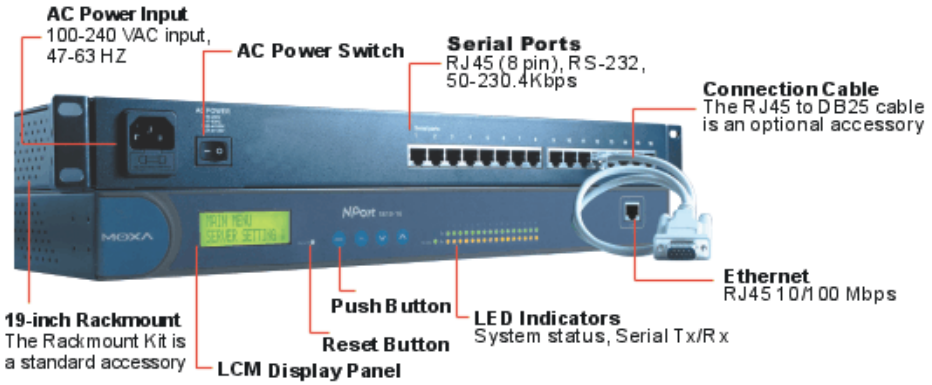
Hardware

☞ Serial 2 Ethernet translate

MOXA UC

MOXA NPort 5610-16

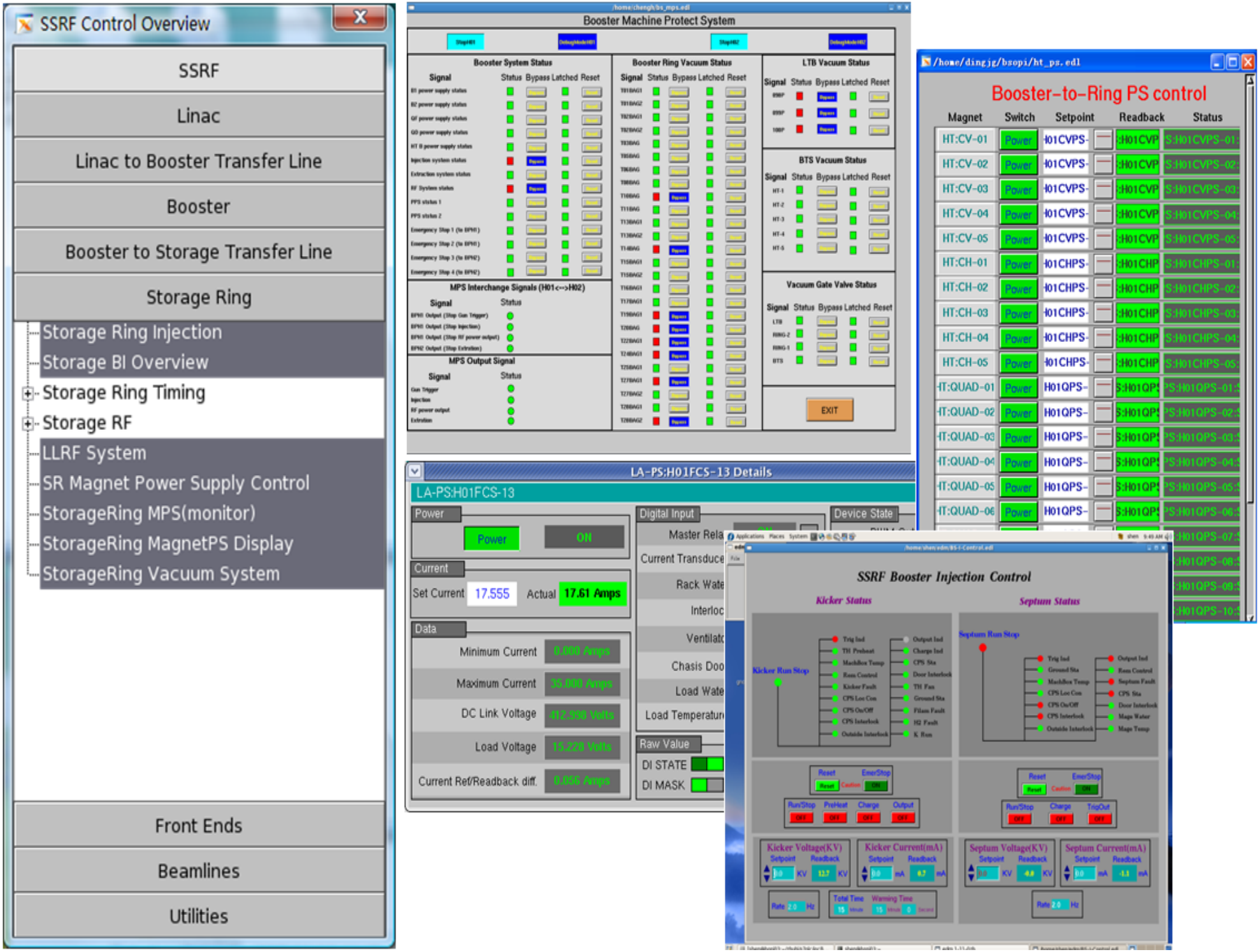
Embedded Linux DI/DO



PLC System

Software System

- The SSRF control system running on EPICS base v3.14.8.2
- OPI
  - EDM and some Python script
- High level physics application
  - Matlab 2007a
  - MCA/LabCA
  - Accelerator Toolbox (AT) & middle layer was adopted.
- Perl/Python, Qt3
- CodeGear RAD Studio 2007(Borland C++/Delphi)
  - For Windows client

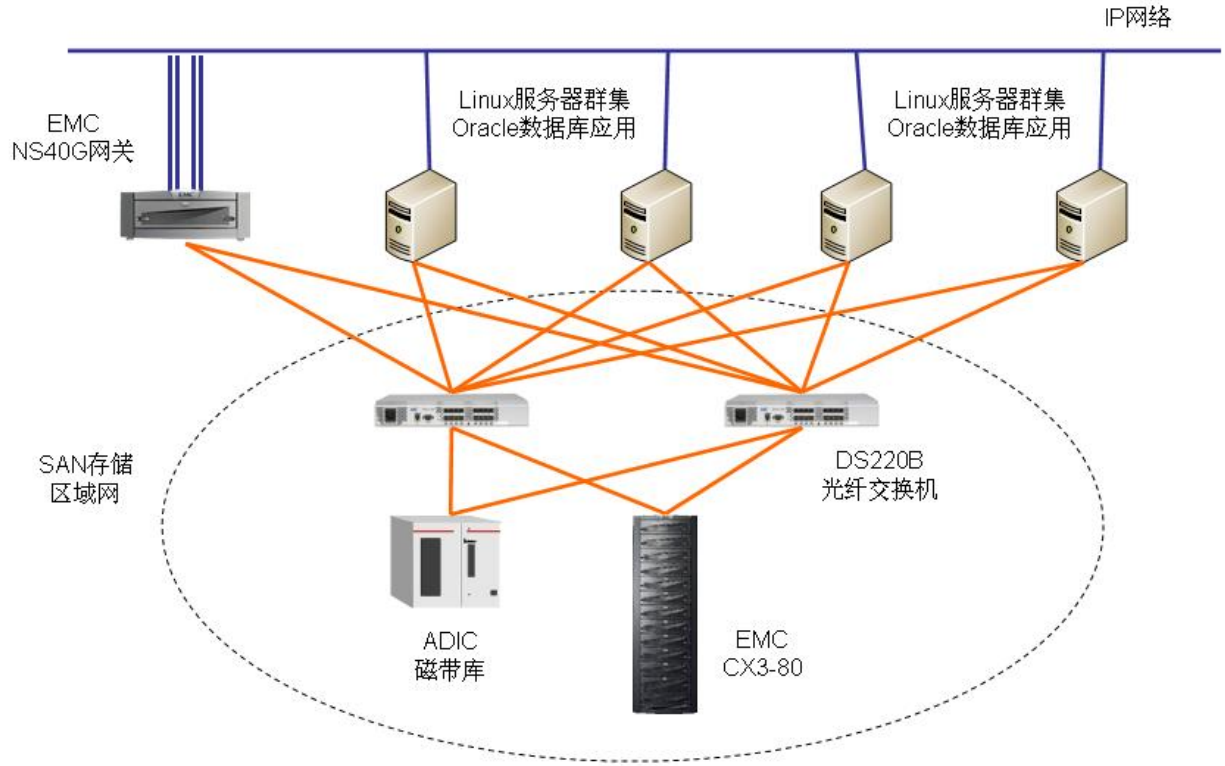

SSRF Control Overview
SSRF
Linac
Linac to Booster Transfer Line
Booster
Booster to Storage Transfer Line
Storage Ring
Storage Ring Injection
Storage BI Overview
Storage Ring Timing
Storage RF
LLRF System
SR Magnet Power Supply Control
StorageRing MPS(monitor)
StorageRing MagnetPS Display
StorageRing Vacuum System
Front Ends
Beamlines
Utilities
Booster Machine Protect System
Booster System Status
Booster Ring Vacuum Status
LTB Vacuum Status
BTS Vacuum Status
Vacuum Gate Valve Status
MPS Interchange Signals (H01<-->H02)
MPS Output Signal
EXIT
/home/dingjg/bsopi/ht_ps.edl
Booster-to-Ring PS control
Magnet
Switch
Setpoint
Readback
Status
LA-PS:H01FCS-13 Details
Power
Current
Set Current
17.555
Actual
17.61 Amps
Data
Minimum Current
Maximum Current
DC Link Voltage
Load Voltage
Current Ref/Readback diff.
Digital Input
Device State
Raw Value
DI STATE
DI MASK
SSRF Booster Injection Control
Kicker Status
Septum Status
Kicker Run Stop
Septum Run Stop
Kicker Voltage(KV)
Kicker Current(mA)
Septum Voltage(KV)
Septum Current(mA)

Centre Database System

- Store the machine parameters and reference information for all stage of machine simulation and running.
- Access and set various accelerator run time configure parameters, failure report and invalid record of all system.
- Will store accelerator runtime data with an enhance channel archive system(under testing)
- Remote access from Internet and web based database access also could be applied.

Database System

- The hardware platform using SAN & database server cluster.
- Now we have tested on the MS SQL Server 2005 and will transfer to Oracle 10g with RAC later.



e-Log System

- Based on center database system
- Using Web2.0 Blog system
- Support RSS
- Integrated with uniform authentication system

SSRF Control System

- Three part of control system:
  - Linac, Booster, Storage Ring
- Sub system
  - Magnet PS, Vacuum,
  - Modulator, e-gun, Transport Line(injection & extraction)
  - Timing, MPS, RF, ID

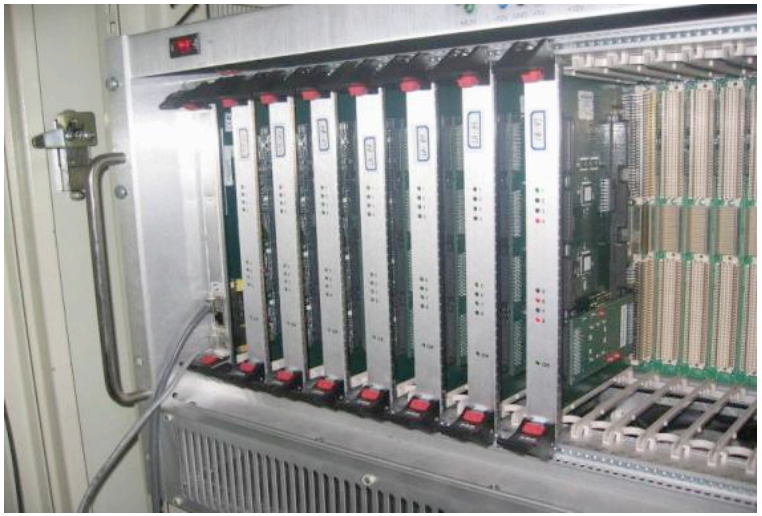
System	**device**	**IOC**	**PV**
Power supply	585	26	65000
Vaccum system	730	25	23298
MPS system	25	3	16842
Timing system	16	16	540

PS Control System

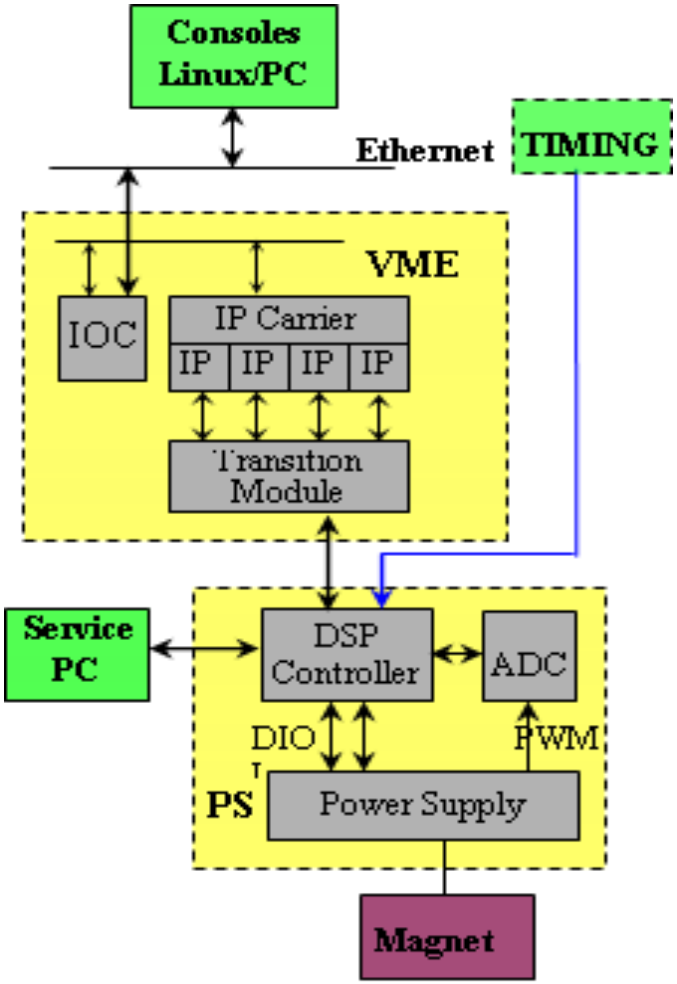
- Over 550 magnet power supplies are used at SSRF
- All magnet PS are digital controlled
- 2 types of digital controller used:
  - SINAP-developed digital PS controller:
    - served for LINAC, Booster and Transport Lines
  - PSI-designed digital controllers (Purchased from DLS Co., Ltd):
    - served for Storage Ring and the Booster Ramp PS.
    - Waveform can be triggered to run with offset current and scaling factor.
    - The SSRF global timing system triggers the waveform to run at repetition of 2 Hz.
- Performance of high stability and reliability has been demonstrated since SSRF commission.

Digital Power Supply Control system

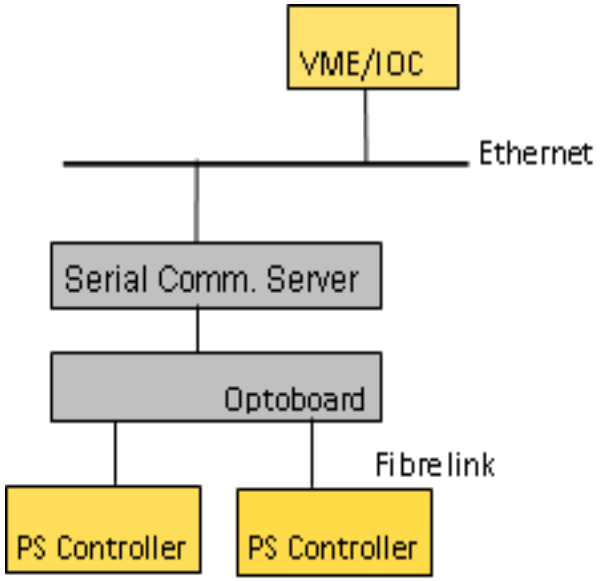
- Two kinds of system
- EPICS integrated



Digital Power supply control system

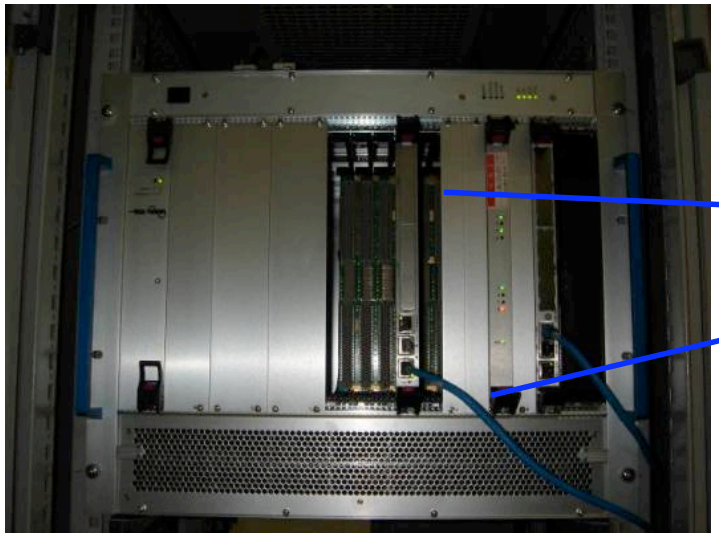


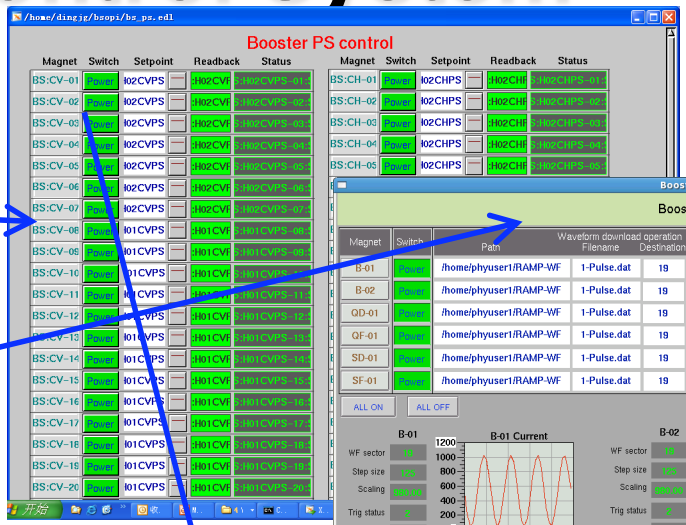
Solution for PSI-designed controller

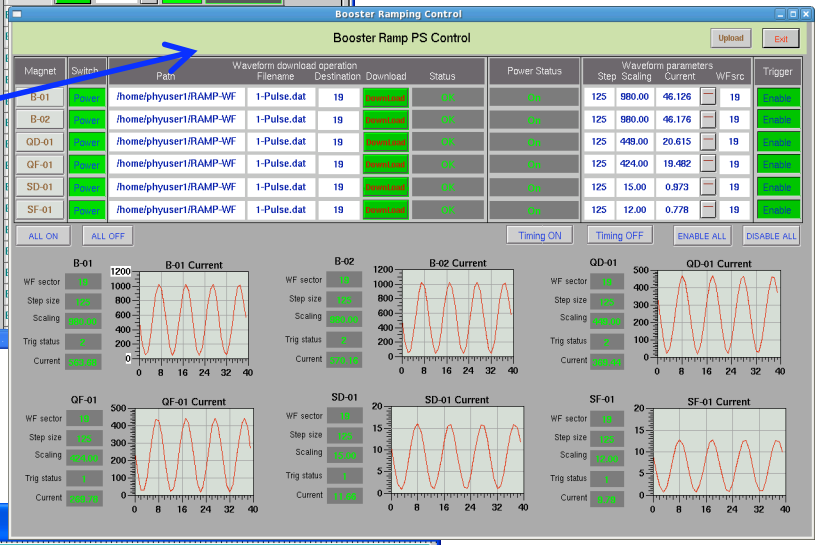


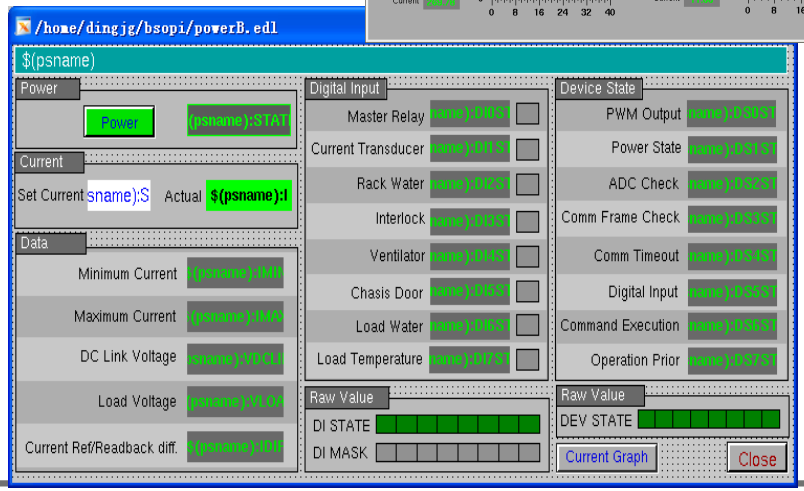
Solution for SINAP designed controller

PS Control System

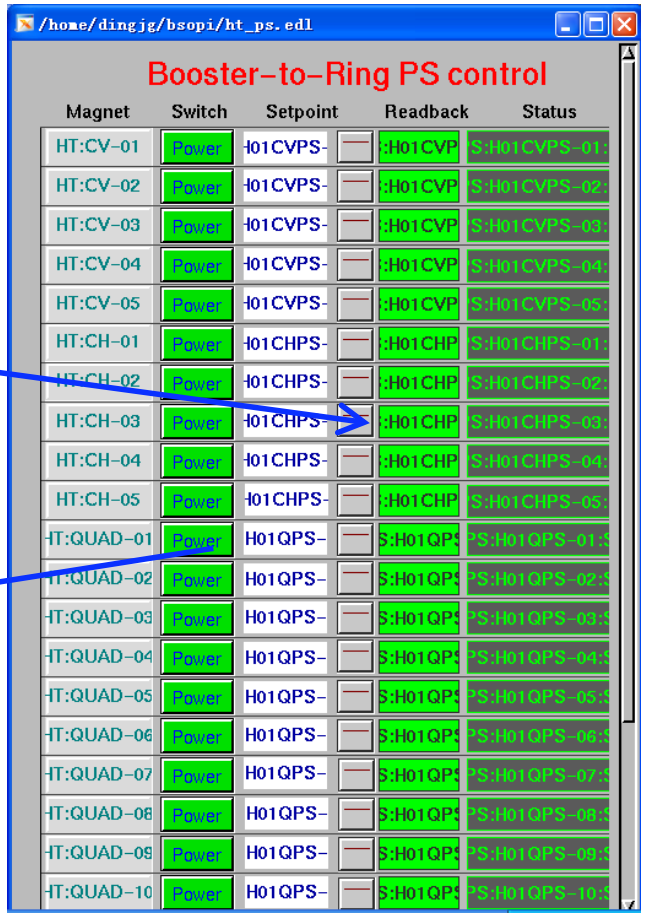


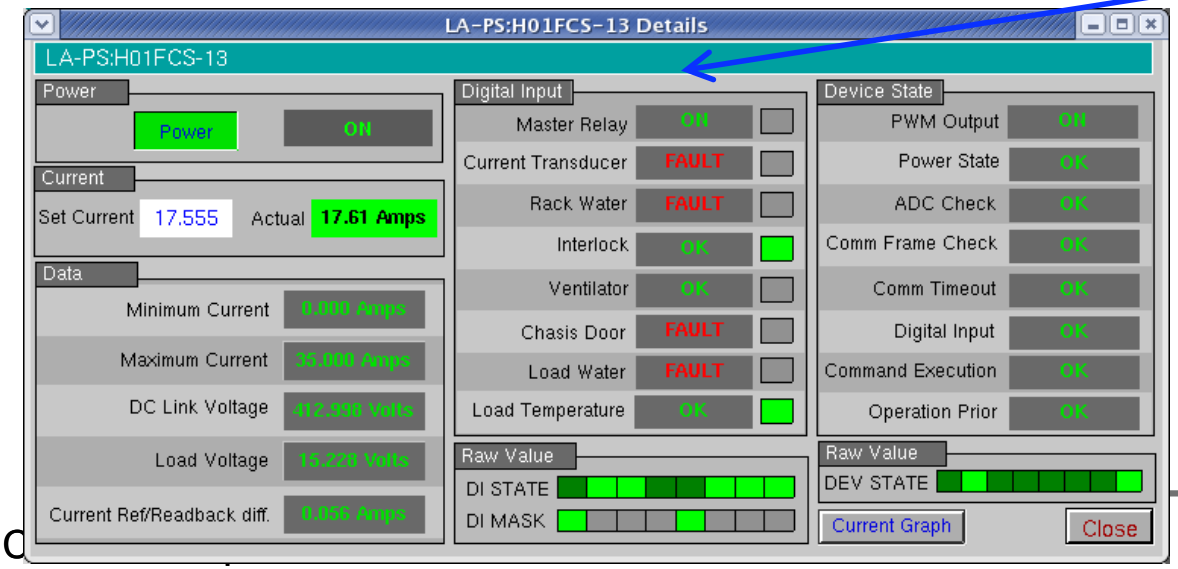






Booster PS Control System - in house design



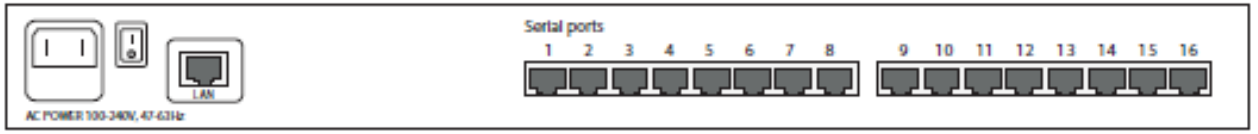


Vacuum Control System

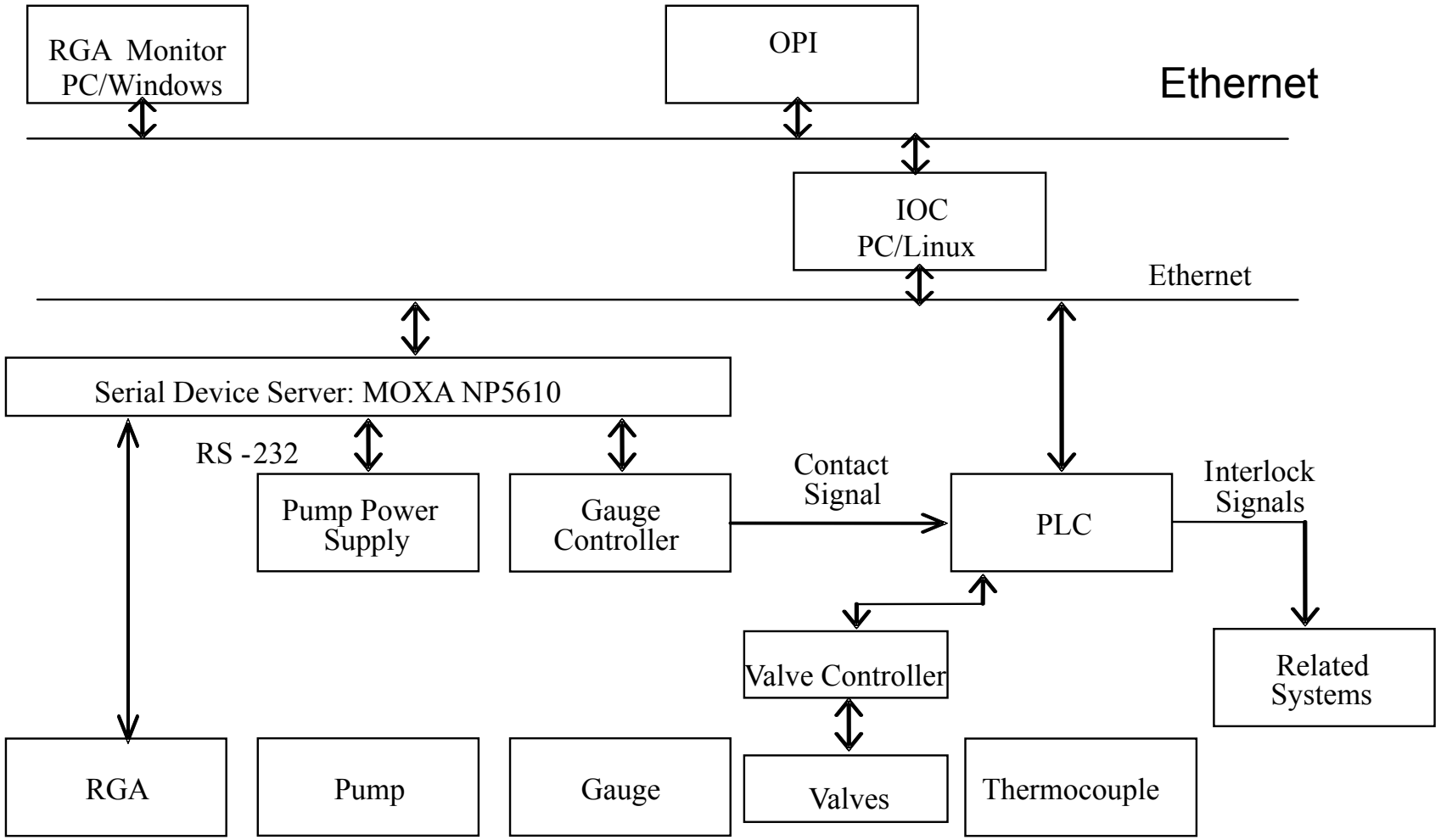
- Device based on serial port
  - Vacuum Gauge: **VARIAN** Multi Gauge
  - Sputter Ion Pump: JJJvac Sputter Ion Pump Power Supply
  - RGA（Residual Gas Analyzer）
  - Vacuum Valve
  - PLC system
- Serial Device Server: MOXA Nport 5610-16
  - Total 53

Front panel of NPort 5600 series

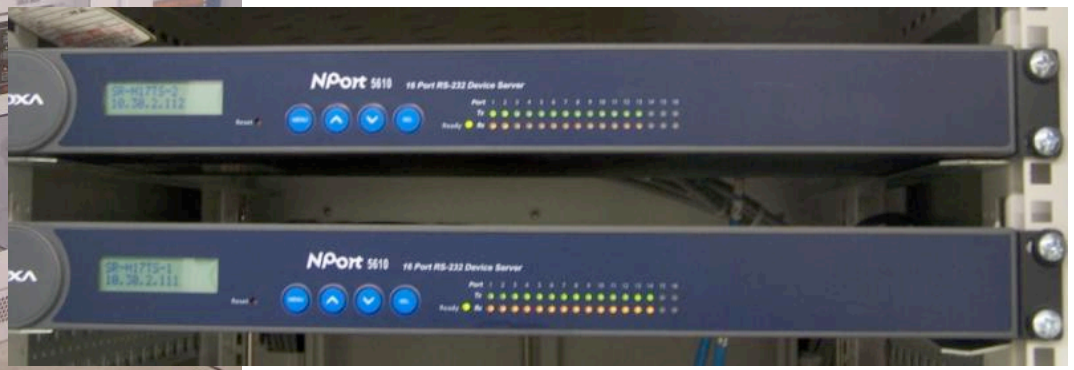
Rear panel of NPort 5600 series (AC Power)

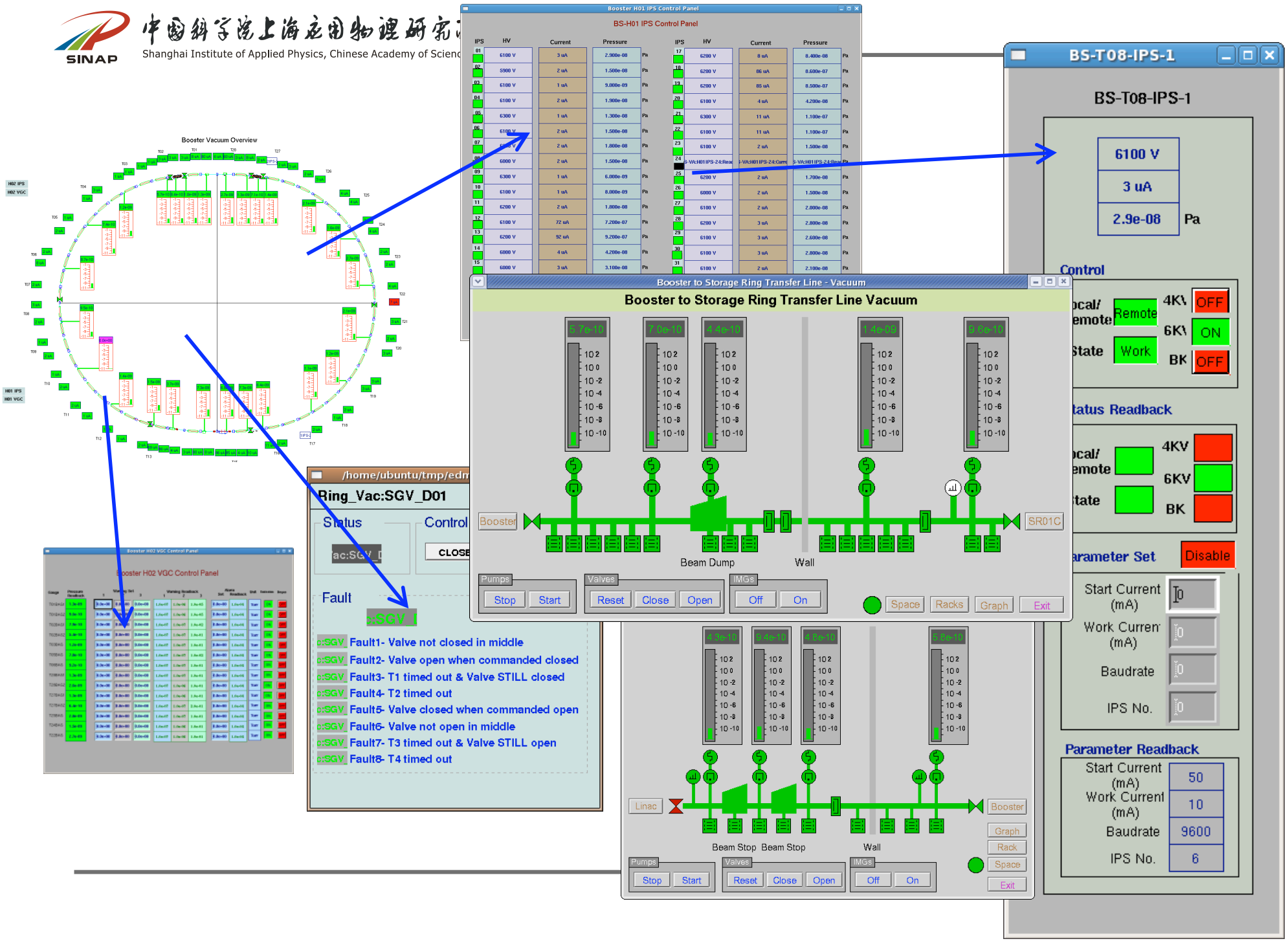


Vacuum Control System



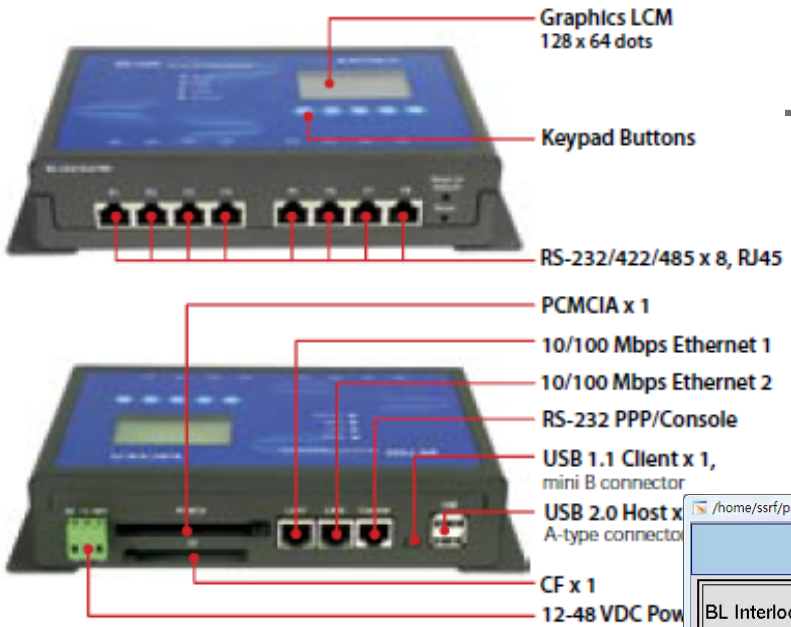
Vacuum Control System




SINAP
中国科学院上海应用物理研究所
Shanghai Institute of Applied Physics, Chinese Academy of Scienc
Booster Vacuum Overview
Booster H01 IPS Control Panel
BS-H01 IPS Control Panel
BS-T08-IPS-1
6100 V
3 uA
2.9e-08
Pa
Control
Remote
Work
4KV
6KV
BK
OFF
ON
Status Readback
Parameter Set
Disable
Start Current (mA)
Work Current (mA)
Baudrate
IPS No.
Parameter Readback
50
10
9600
6
Booster to Storage Ring Transfer Line - Vacuum
Booster to Storage Ring Transfer Line Vacuum
Booster
SR01C
Beam Dump
Wall
Pumps
Stop
Start
Valves
Reset
Close
Open
IMGs
Off
On
Space
Racks
Graph
Exit
Booster H02 VGC Control Panel
/home/ubuntu/tmp/edm
Ring_Vac:SGV_D01
Status
Control
CLOSE
Fault
Fault1- Valve not closed in middle
Fault2- Valve open when commanded closed
Fault3- T1 timed out & Valve STILL closed
Fault4- T2 timed out
Fault5- Valve closed when commanded open
Fault6- Valve not open in middle
Fault7- T3 timed out & Valve STILL open
Fault8- T4 timed out
Linac
Booster
Beam Stop
Beam Stop
Wall
Rack

Control of Insertion Devices

- 5 insertion devices in SSRF at this moment
  - 2 In-vacuum undulators
  - 1 EPU
  - 2 wigglers
- A new model of embedded EPICS controller
  - Moxa UC7420
  - Intel Xscale CPU
  - Linux system
  - Integration remote control for motion control & coil power supplies control



/home/ssrf/prod/opi/edl/insertdevice/wiggler_H14_master_monitor.edl

SSRF H14 Wiggler Control

EXIT

BL Interlock | Local Control | Gap Motor Enable Status | Motor On | Reset Status | Reset

Motor Status Warning

E Stop | Motor Err | Max Limit | Min Limit | Max Overtravel | Min Overtravel

Gap Position Monitor

Gap Current Position 17.0000 mm | Error Active | Motor Stop | Status

Set Gap Position 17.0000 | Gap Motor On

Gap Position Feedback 17.0000 mm | All In Positon

Gap Moving

Gap Tolerance Position 0.0000 mm | Motor Move Complete

17.0000 m | 17.0000 m | 0.0000 mm | 0.0 | cur | set | tol

Gap Velocity Monitor

Set Gap Velocity 0.2000 | Gap Velocity Feedback 0.2000 mm

Power Supply Control

Device	Switch	SetPoint	ReadBack	Status	
H14CH-2	OFF	7.2000	0.0184	Off	
H14CH-1	OFF	1.2000	0.0236	Off	
H14CV-2	OFF	0.5500	0.0184	Off	
H14CV-1	OFF	0.2500	0.0201	Off	

Stop

Status

/home/ssrf/prod/opi/edl/insertdevice/ivu_H15_master_monitor.edl

SSRF H1

BL Interlock | Local Control | ID Status | ID Gap

CPU Status

CPU Load 11.98

Memory Free 5266

Boot Time Tue Mar 3 1

IOC Time Sat Apr 25 1

Detail

IVU Running Monitor

Related Value

UpStream_UpLAE 5.4001 mm

UpStream_DnLAE 2.9966 mm

DnStream_UpLAE 4.9448 mm

DnStream_DnLAE 3.3136 mm

Current Value

Up Stream Gap 8.3967 mm

Down Stream Gap 8.2584 mm

IVU25 Taper -0.1383 mm

Setting Value

Set Gap Position 8.400

Set Taper Position -0.140

Set Gap Velocity 0.200

Start | Stop

MAX Gap | UnLock | Reset

Running Status

IVU25B Group Err

Position Group Alarm

UpStream Motor Run

DnStream Motor Run

Position Lock

Pos Working

Pos Reached

Warning&Alarm Value

	Warning Value	Warning	Alarm Value	Alarm
Gird Temp	90.0000		100.0000	
Water Temp	40.0000		50.0000	

Water Flux and Temperature

	FTT1	IB1	FTT2	IB2	AB1
Flux					
Temp	29.5000 Cel	29.4000 Cel	29.9000 Cel	32.6000 Cel	

Explanation: Left Warning / Right Alarm

Maintain Interface

Gird Temperature

	1	2	3	4	5	6	7	8	9	10
UpGird	29.1000 Cel	28.2000 Cel	28.5000 Cel	28.8000 Cel	29.0000 Cel	28.4000 Cel	30.0000 Cel	28.1000 Cel	28.2000 Cel	29.0000 Cel
DnGird	29.0000 Cel	29.0000 Cel	33.0000 Cel	30.6000 Cel	28.0000 Cel	28.7000 Cel	28.2000 Cel	30.8000 Cel	27.8000 Cel	29.3000 Cel

/home/ssrf/prod/opi/edl/insertdevice/epu_H08_master_monitor.edl

SSRF H08 EPU Control

BL Interlock | Local Control | Both Motor Enable Status | Both Motor On | Gap | Shift | Reset Status | Reset | Abort Status | Stop

Gap Motor Status Warning

E Stop | Upper Left | Upper Right | Lower Left | Lower Right

Kill Max | Kill Min | Overtravel Max | Overtravel Min

Shift N

Kill Left | Kill Right | Overtravel Left | Overtravel Right

Gap Position Monitor

Gap Current Position 72.6413 mm | Error Active | Motor Enable Status | Gap Status

Set Gap Position 72.6400 | Gap Motor On

Gap Position Feedback 72.6400 mm | All In Position

Gap Moving

Gap Tolerance Position -0.0013 mm | Motor Move Complete

Upper Left Position -12.6800 mr

Upper Right Position -12.6803 mr

Lower Left Position 12.6787 mm

Lower Right Position 12.6789 mm

72.6413 m | 72.6400 m | -0.0013 m | 0.0 | cur | set | tol

Motor Move Status | Motor Stop | Status

Shift

Shift Current Position 0.0000 mm

Set Shift Position 0.0000

Shift Position Feedback 0.0000 mm

Shift Tolerance Position 0.0000 mm

Shift Inner Position 0.0000 mm

Shift Outer Position -0.0002 mm

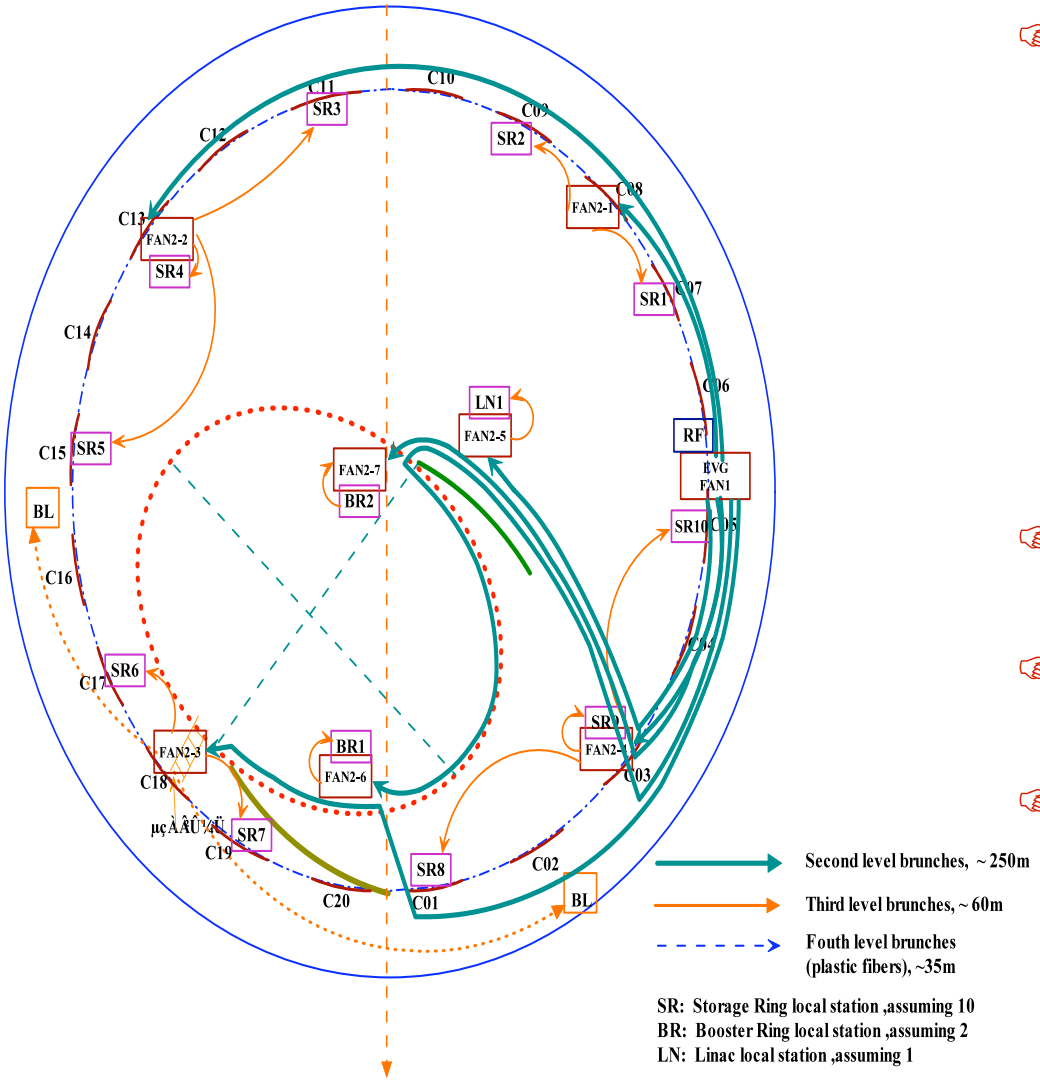
Gap Velocity Monitor

Set Gap Velocity 0.1000 | Gap Velocity Feedback 0.1000 mm

Shift

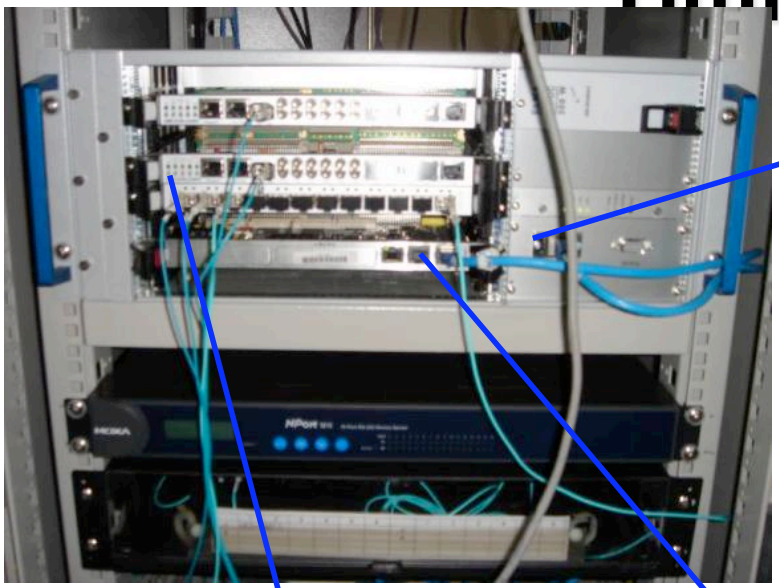
Set Shift Velocity 0.2000

The event timing system

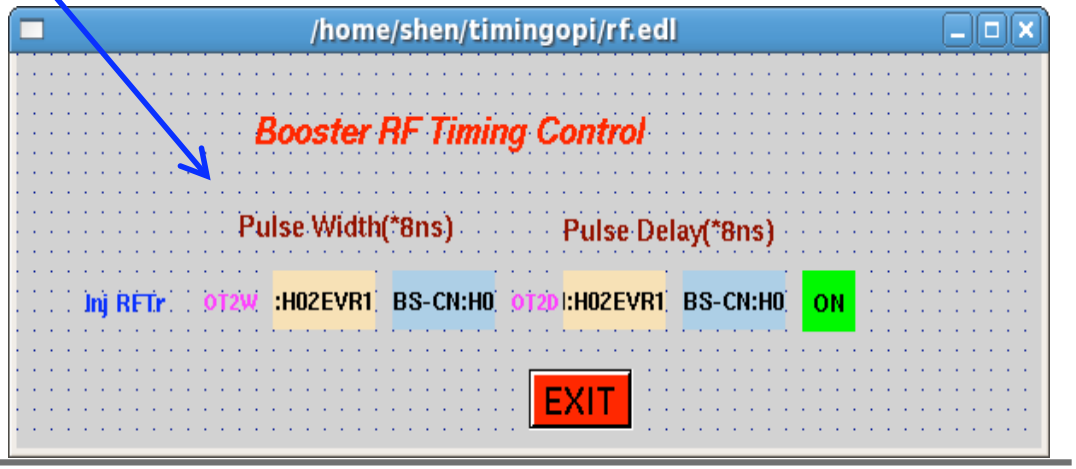


- New event timing system
  - Structure is simple used broadcasting method
  - Low Jitter with distributed RF clock
  - Run on the EPCIS environment, base 3.14.x
  - Easy to extend
- Compact network based on characteristic event system.
- All EVRs are placed on timing crates and BI local stations
- All trigger outputs integrate with hardware interlocks

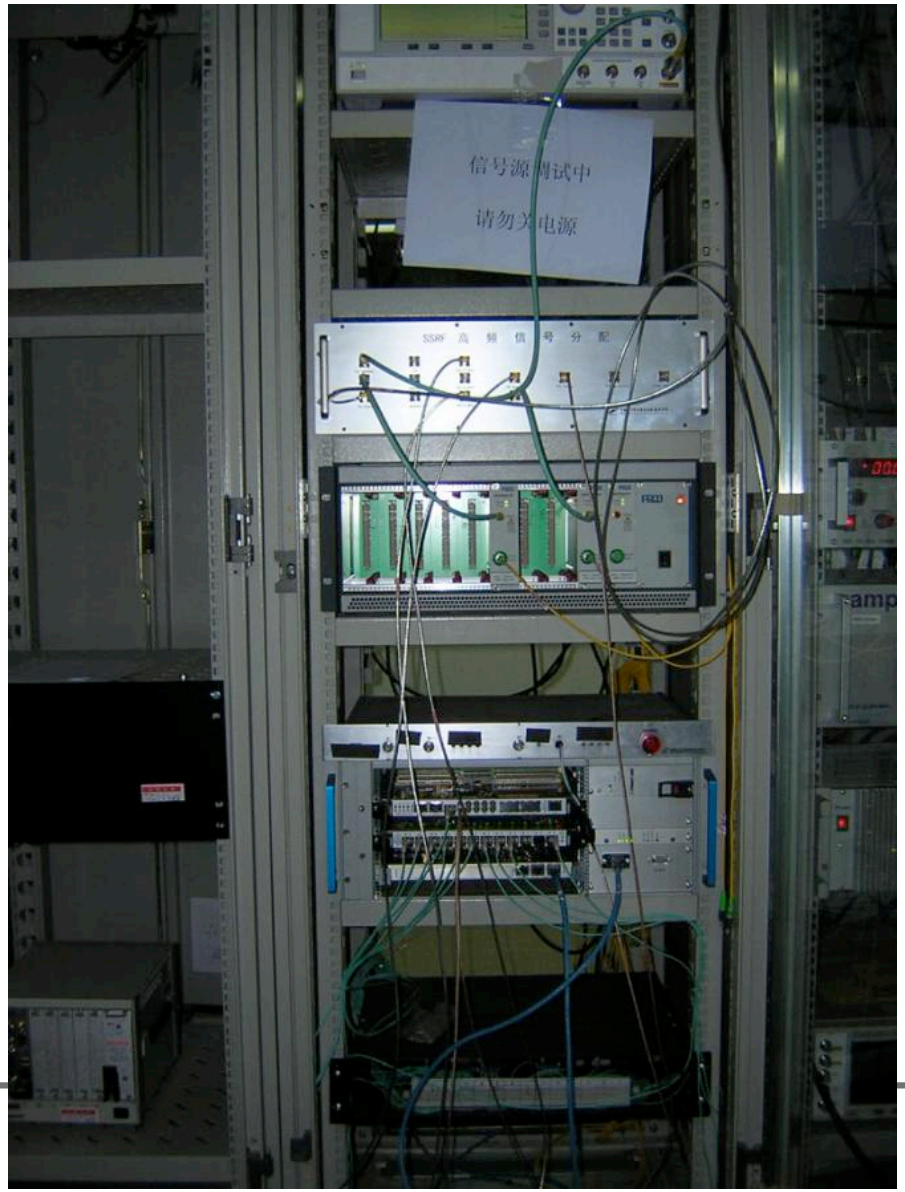
Timing System



- Micro-Research products
  - EVG-230
  - EVR-230
  - Fout-12,
  - OTB-200
  - TTB-200
  - GunTX-200
  - GunRC-200



RF & Timing Event Distribution



Master Signal Generater

RF Signal Distrubution Unit

Timing & Eent Signal Generator

Fiber (Om3) Distribution Unit

Performance

- The RMS jitter of gun trigger relative to RF reference is 10.72ps, which includes the jitter of e-gun and oscilloscope.
- The RMS jitters of other injection and extraction trigger are less the 30ps.
- Performance are satisfied with the requirements of physical design.

MPS System

- SSRF MPS has three levels of protection.
  - Fast hardware interlock subsystem: 1mS
    - For beamline fast photon shutter protection
    - custom-built TTL logic gate array circuit,
  - General hardware interlock subsystem: 30mS
  - Software interlock subsystem: 50~100mS

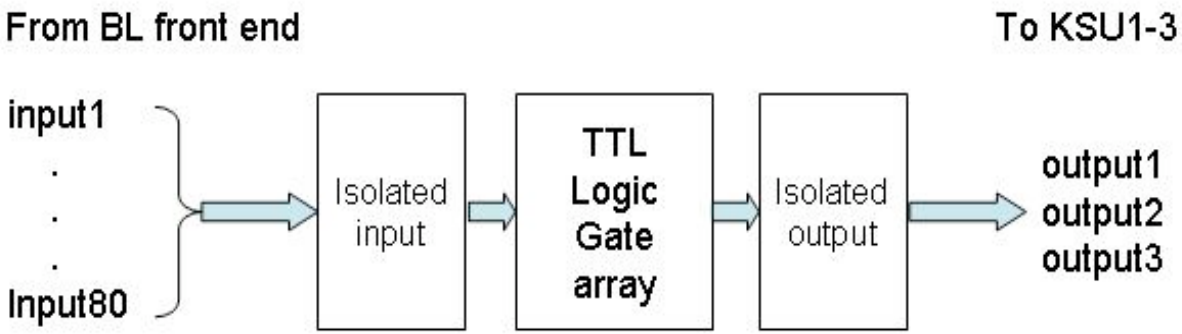
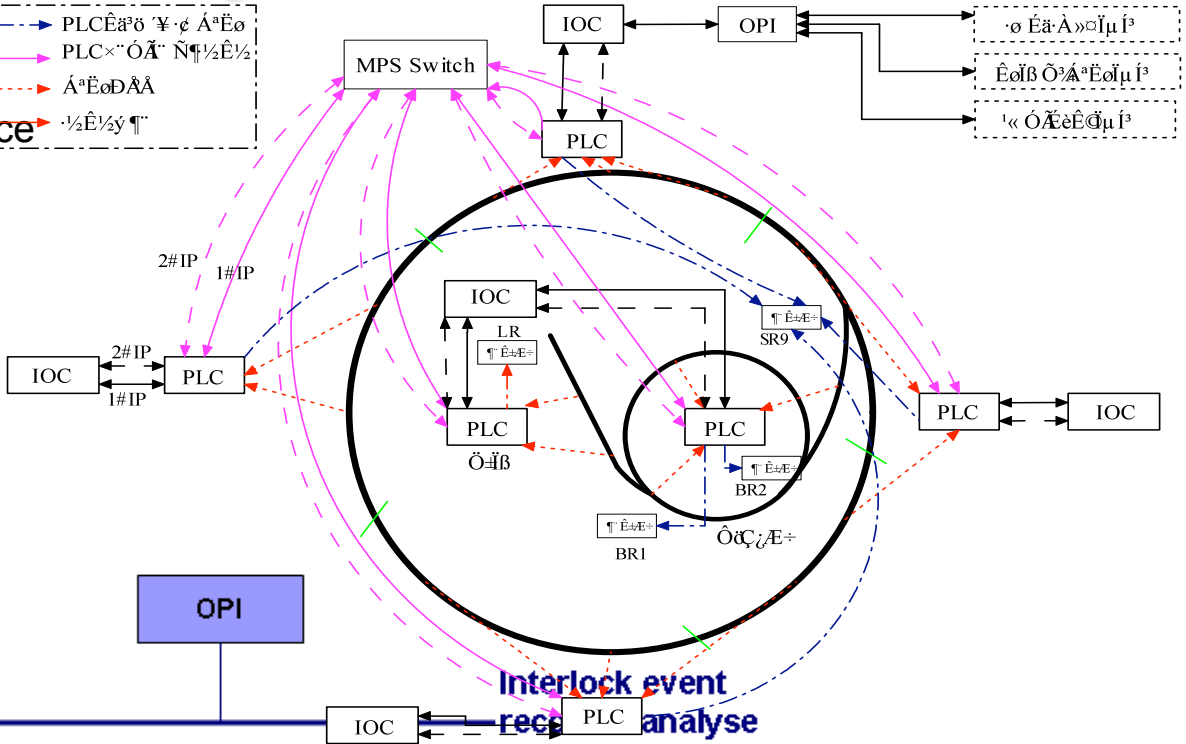
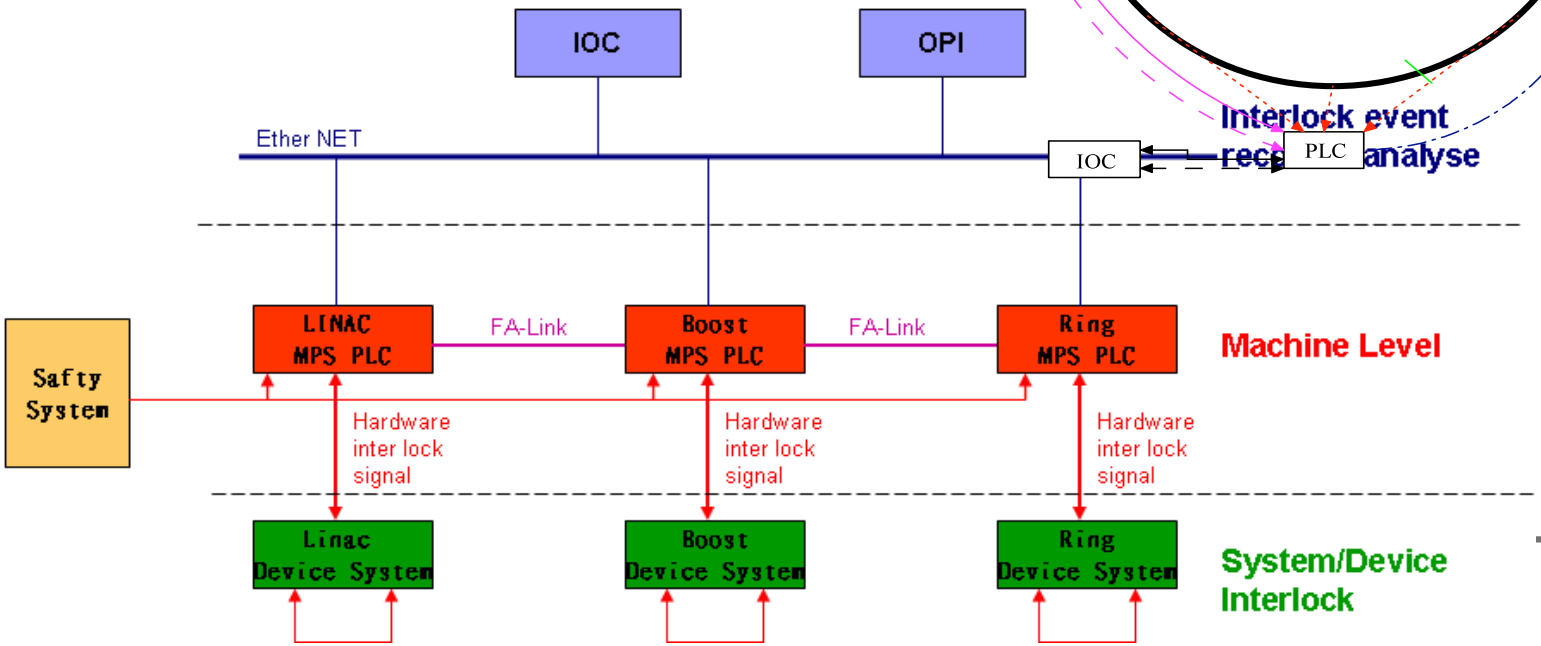


Diagram of fast hardware interlock controller

MPS System

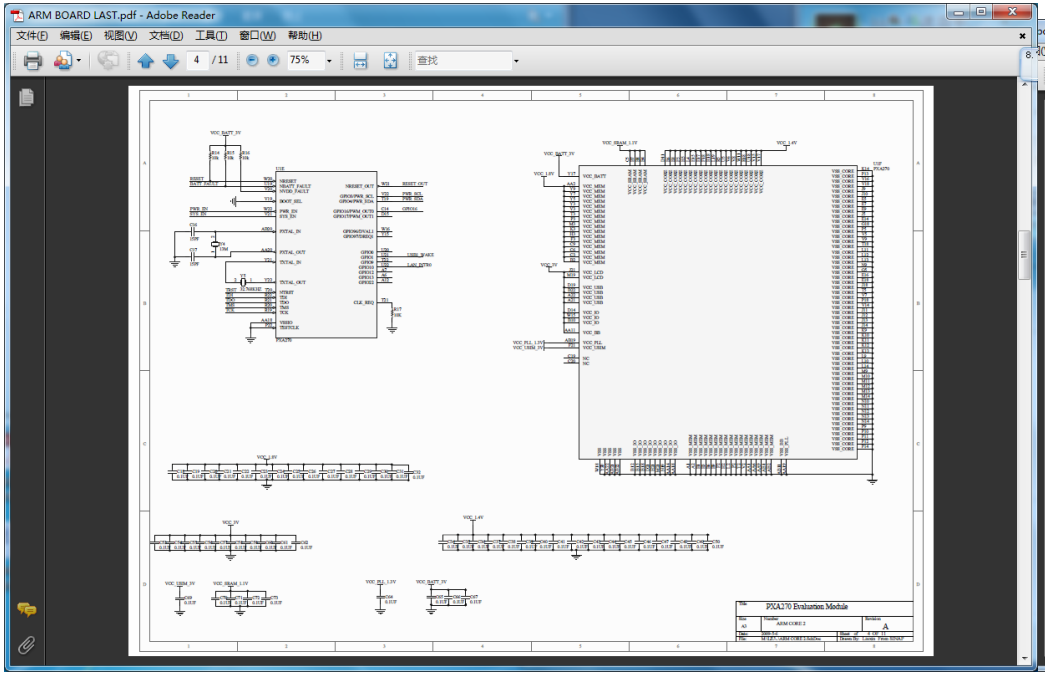
- 3 parts：
  - Accelerator & beam line device interlock
  - Utility system
  - Safety system
- Hiberarchy
  - The whole machine layer
  - Linac, boost, ring layer
  - Sub system layer
  - Device layer

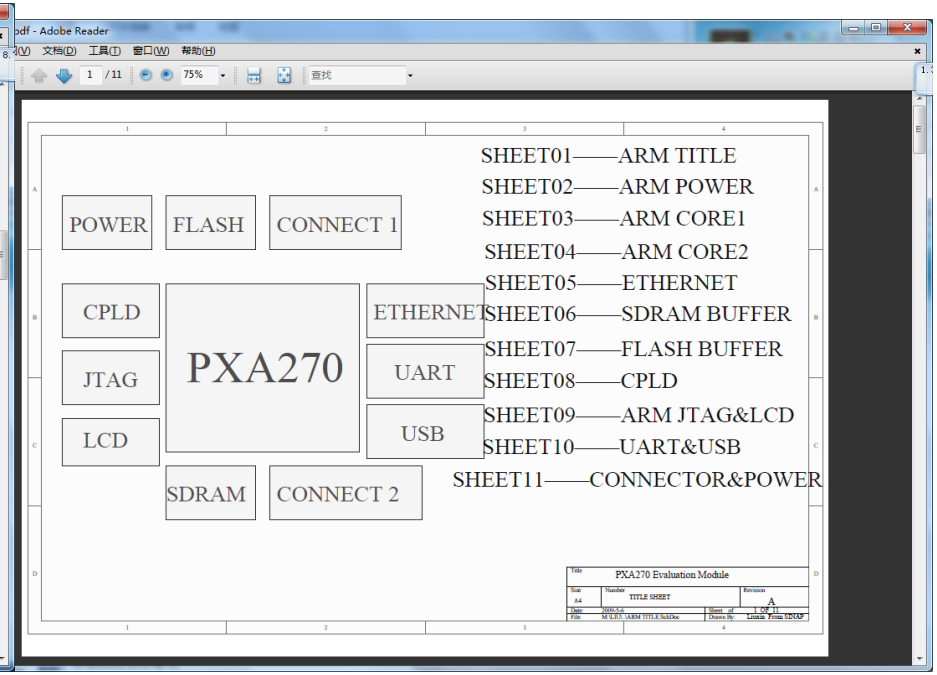




Fast interlock system

- New controller
  - ARM/FGPA
  - New PLC Mouduler@ Yokogawa FM3

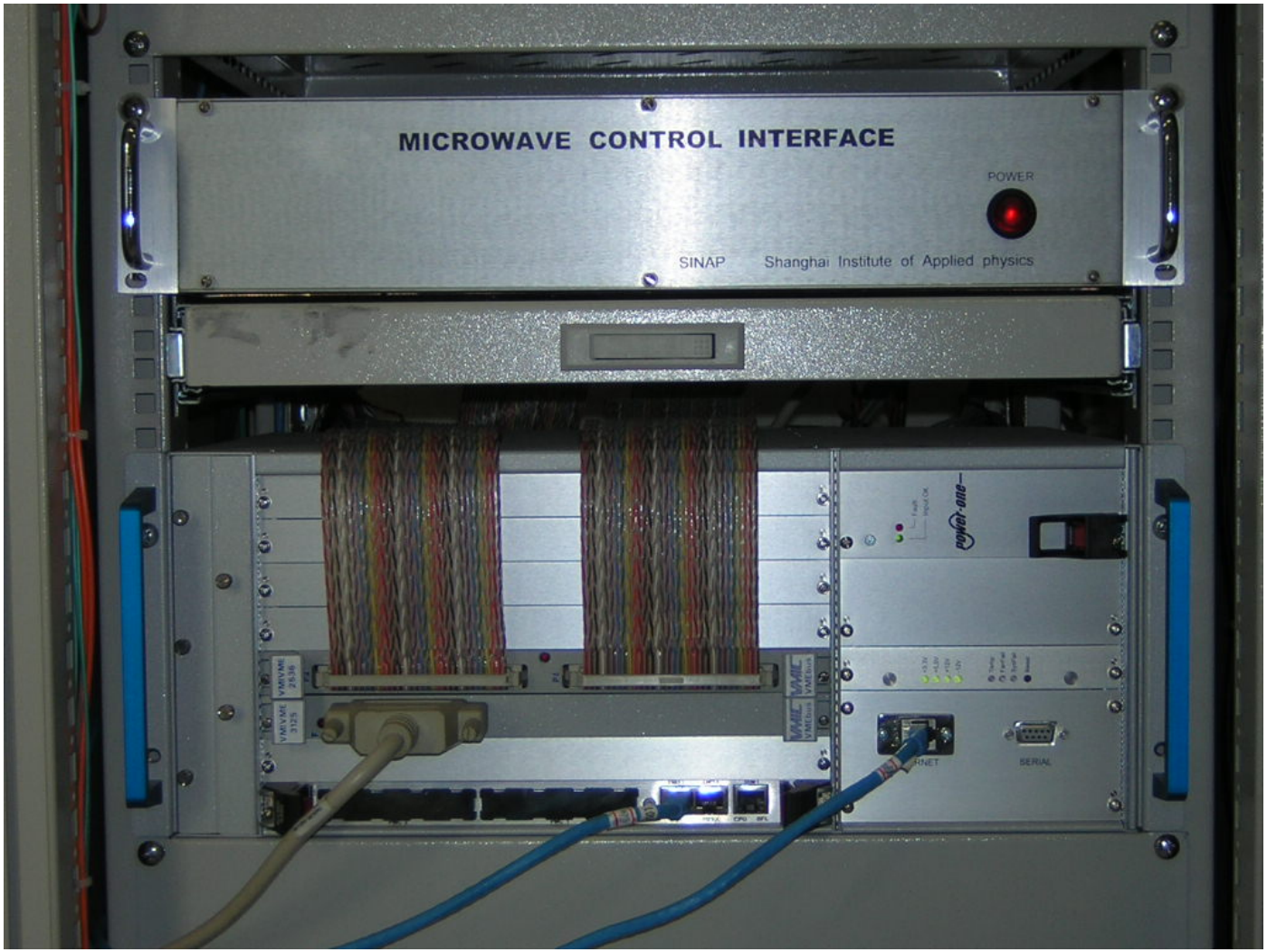




The RF System control

- Linac RF system is in house design
- Booster RF is a turn key system
  - Integrated with EPICS system
- Integrated the whole storage ring RF system
  - VME/PLC
  - EPICS
- All the RF system can remote control at center control room

Linac RF Controller



RF Devices Interface

SSRF Design

VME Controller

MVME 5500 CPU

VMIVME 2536

Digital 32 In/32 Out Ch

VMIVME 3125

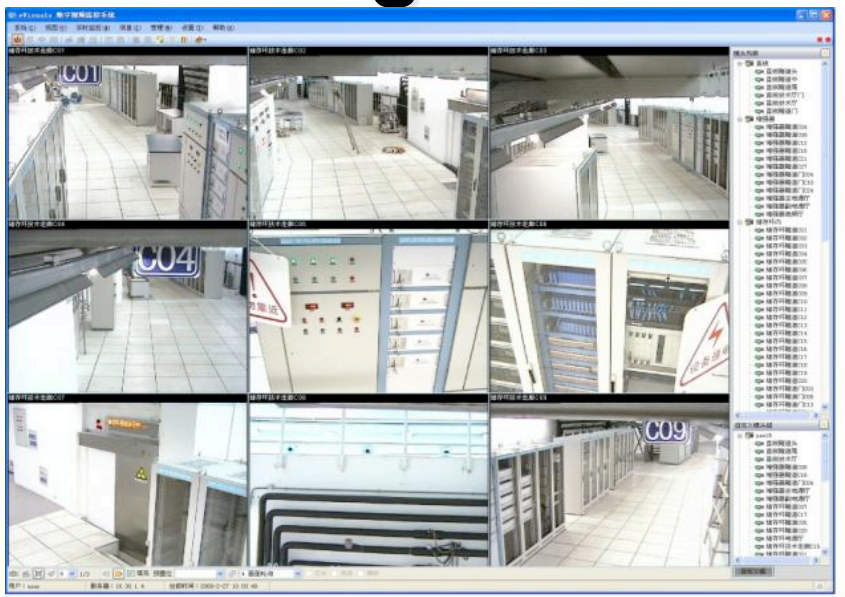
Analog 32 Ch A/D

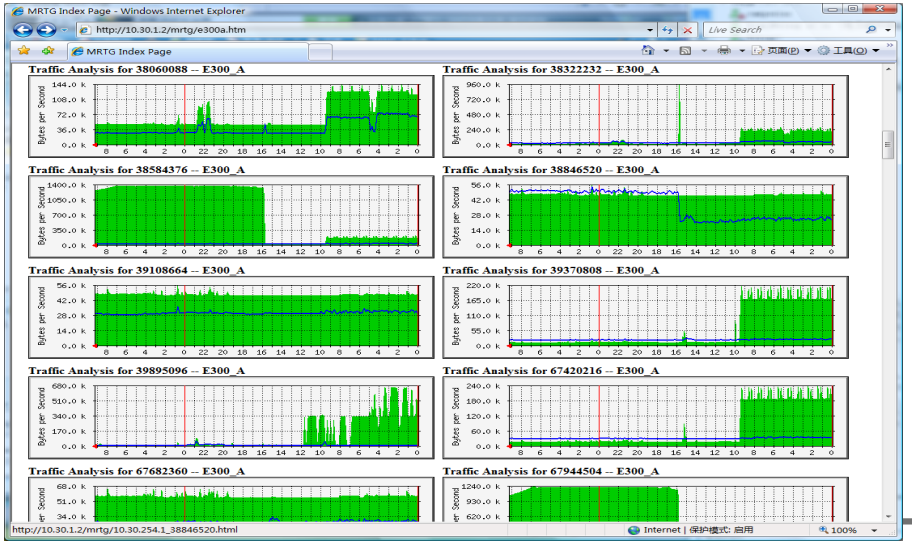
Isolated Interface

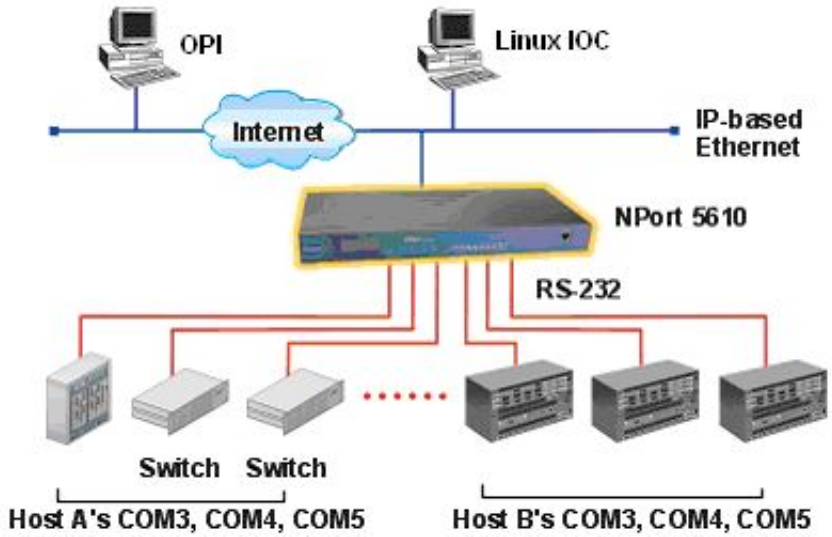
SSRF-Design EPICS Driver

Remote manage & debug

- Video & Audio system based on network
- Device management
- Remote monitor: VME, Switch, UPS etc
- Network management system
  - Based on SNMP
- Email、SMS alarm system(Next)
- EPICS gateway between ACS/BLCS
- Control system Live CD







Center Control Room

- HP7700 OPI PC(18) in the Control Room
- All the OPI run on the Linux Fedora 7 and in ssrf.ac.cn domain.
- OPI system running at control system uniform runtime environment.
- The edm file store on NFS file server and all the client can access it by a start script.


SR-RF status
BS-RF status
2008/02/27

Conclusion

- Set up a distributed controls system based on EPICS.
- All device control system had finished system construct, include install, online testing and software development.
- The LINAC, Booster and Storage Ring control system were finished and used in daily operation.
- High level physics application and control system OPI panel can run normally.
- The control system was successful during the machine commissioning. In general, most function of control have been reached on design goal.

Conclusion

- Uniform hardware and software design
- Ethernet everywhere with an uniform network
- Soft IOC used reduce the cost
- Industrial and commercial technique used widely
- Integration of IT technique

ACKNOWLEGEMENT

☞During our design of software and hardware, under construction of control system a, we have got a lot of help from many experts, specilists on the world such as SLAC, SLS, KEK,DIAMOND, Micro-Research, PAL etc. We appreciated for their sincere support.

Thank you for your attention!